TITLE: COFFEE ROASTER AND METHOD

RELATED APPLICATION:

U.S. Provisional Application SN: 60/261,124, priority claimed.

BACKGROUND:

Green unroasted coffee beans remain useful for extensive time periods. When roasted, unground coffee beans begin to lose flavor in a day and shall have lost almost all flavor in a week. Ground coffee deteriorates even faster.

As the people become more sophisticated about food and coffee, the consumer market demand grows for better quality coffee beverages. Specialized coffee shops have arisen to meet this demand. However, many of these shops provide no in-store roasting. Roasted beans are shipped from a central location to shops all over the country. The coffee served at these shops has spent the prime of its life in transit. The pre-roasted whole-bean coffee one buys in supermarkets is even older.

Freshly roasted and ground coffee is vastly superior compared with these pre-roasted products. Various systems are known that attempt to roast green coffee beans and otherwise process them shortly before grinding and using them to make fresh coffee. See for example, U. S. Patents 3,964,175, 4,326,114, and 6,123,971. These disclosures recognize the value of rapid cool down of roasted beans but suffer from various process steps that prevent production of a good quality product. For example, these systems fail to enable the operator to visually inspect the roasting bean color to control various process steps that can produce a better quality final roasted bean.

Various characteristics of the roasting beans can be used to indicate or measure quality during the roasting and cooling cycle, such as the color of the roasting beans, smell of the rising aroma, crackling sounds of the beans, and the length of time, roasting energy consumed, and bean temperature. Technical problems must be solved to effectively use one or more of these characteristics. For example, the generally known fluidized bed coffee bean roaster uses streams of radiantly heated hot air to carry, circulate, and roast the beans. However, the operator of these systems cannot observe the individual bean color but only a swirling mass during the roasting. Operation of

other household units of the drum type cannot visually inspect the beans while roasting. All of these units do not attempt to minimize the smoke produced such that they need to be vented or used outside to avoid creating a polluted environment. Similarly many of these units fail to collect chaff and spread chaff over an already polluted environment. Most of the household fluidized bed units roast only 2 to 3 oz. (1/4 to 1/2 cup) of green beans and have little tolerance for different amounts. These limitations are due to design but are mainly due to the principles of operation and power use of the fluidized bed devices.

SUMMARY OF EXEMPLARY EMBODIMENTS OF THE PRESENT INVENTION:

The roasters according to the principles of the present invention provide substantial benefits over previously known systems and enable the operator to use one or a combination of up to all of the above mentioned characteristics of roasting coffee beans while avoiding or solving the above mentioned technical problems.

One exemplary embodiment according to this invention includes a small batch coffee roaster for the home and restaurant markets to produce automatically a repeatable roast coffee bean in the 1/2 - 4 green bean cup range (3 oz. to 1 1/3 lbs.) which will give optimal control of

roasting bean color which is the main determinant of doneness, fast cooling of the beans once roasting is complete, collection of chaff, and elimination of most smoke and odor. This embodiment enables the operator to smell a small amount of smoke and to listen for crackling sounds as a further or alternate indication of doneness.

Another exemplary embodiment according to the principles of the present invention includes an alternate more effective chaff catching, smoke filtering, and processing design and technique. This embodiment lends itself well to not only 1/2 - 4 cups of green beans including, if desired, one or more layers of beans for home or commercial use.

All embodiments are capable of providing a roasting method that preferably substantially roasts the beans by conduction heating when they are at the rest so that color can be observed through a transparent cover. As roasting heat is applied by conduction, a blower exhausts the air and steam through a filter that traps most smoke particles and circulates air within the pan at an air speed that does not disturb the resting, roasting beans. It is preferred, for multiplayer roasting beans, that the blower move the air at high speed to agitate, stir, or circulate the beans for a short time and then cut-off or gradually reduce to

low speed to allow the beans to come to rest again for at-rest roasting. Because the blower operates at increased speed for one or more short time periods, the beans retain most of their residual heat and are not significantly cooled while they are stirred or swirled about the roasting chamber. The roasting continues with the beans retaining most of their residual heat when the blower speed is reduced and the beans come to rest. Preferably, the heater continues to supply heat energy through the at-rest roasting and the stirring cycles. As described below, these cycles repeat as necessary until the operator believes the beans are almost fully roasted. Due to exothermic processes within the beans they continue to heat up when external heat is removed so they are subject to external cooling slightly before the final roast color is seen. Although some chaff will be collected by air currents during the slow speed phase, most chaff will be collected during the high blower speed phase. The subject systems can roast the beans by a process that separates the roasting and cooling phases even though the roasting beans are air stirred because the residual heat of each bean is not removed until the final rapid cool down phase, more fully described below. Systems according to the principles of the present

invention lend themselves well to use electricity as the only needed source of energy for all system functions.

DESCRIPTION OF DRAWINGS

Other and further benefits and advantages of systems and methods according to the principles of the present invention will become apparent with the following detailed description of exemplary embodiments when taken in view of the appended drawings, in which:

Figure 1 is a pictorial view of a vertical cross section through the center of one exemplary embodiment according to the principles of the present invention.

Figure 2 is similar to **Figure 1** showing an alternate embodiment according to the principles of the present invention.

Figure 3 is similar to **Figure 2** showing a single layer of beans therein and the general airflow paths generated by the blower at low speed.

Figure 4 is similar to **Figure 3** depicting the beans and airflow and chaff with the blower at high speed.

Figure 5 is similar to **Figure 3** depicting a multi-layer mass of green beans in the pan.

Figure 6 is similar to **Figure 5** depicting the beans during high blower speed.

Figure 7 is a section view of the pan and beans taken along line 7-7 of **Figure 6**.

Figure 8 is similar to **Figure 2** for a further alternate embodiment and showing general blown air flow thereof.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS OF THE INVENTION

With reference to Figure **1**, a coffee bean roasting system **10** according to the principles of the present invention includes a metal skillet-like pan **12** having a suitable shape and size to accommodate one or more layers of green coffee beans and function as a roasting chamber therefor. In this example pan **12** is circular but could be octagonal, hexagonal, or other suitable shape with a bottom that is generally flat or one which could be slightly sloping toward the center, if desired. Legs **42** support the pan and other assemblies above a counter top or other suitable surface. The pan bottom defines a center opening **14** to enable airflow and accommodate the shaft of motor **24** that drives a radial blower **26** as more fully described below. Brackets or other suitable members (not shown) mount AC motor **24** to the pan such that blower **26** rotates to cause air to draw and to circulate within the roasting chamber.

Pan **12** cooperates with removable transparent cover **14** to close the roasting chamber. Cover **14** is flat or dome shaped and is preferably made of glass although other materials are possible. Cover **14** defines an opening **15** generally at the top thereof. A filter and chaff catcher assembly **16** mounts to top **14** about opening **15**. Assembly includes a chaff catching cup **18** the lower portion of which is solid and the upper portion of which is defined by screen **19** with openings of about **1/8** inch that permits the passage of chaff but denies the passage of coffee beans. A solid baffle **21** forces the exhausting gasses downward below the baffle, small mesh screen **9**, and an upper screen portion **21** that permits the gasses to pass. A solid top or cover **23** prevents gasses from exhausting out the top of assembly **16**. White filter medium **22** serves to filter out smoke particles and odor filter **25** filters most but not all odors so that the operator can smell the aroma of the roasting beans. Filter **25** could be a carbon filter. Filter medium **22** could be selected to be substantially within the range of a 1.0 to 0.1 micron HEPA filter for smoke removal generally available in the industry. The filter opening size would depend upon the size and extent of the smoke particles the manufacturer desires to emit into the ambient. The assembly can be mounted to the glass top or

dome by various bonding materials such as epoxies or adhesives and screw type devices to enable removal of chaff and catching cup and occasional filter replacement. It is preferred that the continuous edge of top **14** include a suitable sealing material **31** such as silicones to substantially prevent air circulating within the chamber from escaping between the pan and the dome.

System **10** further includes a control panel **30** that includes certain push buttons or dials **32** that enable the operator to set automatic heat energy and blower applications or manually set or over ride such settings. Power cord **34** provides standard house **110**volt house power or **220**volt power as desired. Power cord **36** provides power and speed control to the motor **24** and power cord **38** provides heat energy to resistive heater coil or cal rod **40** that in turn heats the bottom of pan **12**.

In one method example, the unit of figure **1** was operated in the manual mode. Approximately one cup of green beans was spread evenly on the bottom of the **12-inch** diameter pan **12** with four-inch high sidewalls. Opening **14** was **3** inches in diameter as was the opening in the top of glass dome **14**. The blower **26** was a LAU radial blower #C2895767, 3 and 13/16th inches by 1 and 1/32nd inches high

radial blower with **30** back-curved blades, CCW Rotation in plan view.

The glass lid **14** with filtration assembly **16** attached was placed on the pan to close the chamber.

The heating rod **40** was energized for **10-12** minutes at **1400** Watts.

The stationary layer of roasting beans was visible through the glass lid and the sounds (crackling) of roasting were clearly heard. The aroma of roasting coffee beans was discernable without excessive smoke filling the room.

Once the required or sufficient degree of doneness was perceived by sight, smell, sound, and/or time, the heating unit was turned off and the cooling unit (the motor-blower **24-26**) was turned on at about **6500** RPM.

Some smoke was visible on the outside of the filtration unit early in the cooling cycle. As the roasted beans were swirled around inside the roasting chamber during the cooling cycle, they were being cooled by the outside drawn and circulating air. As they swirled around, chaff was loosened and deposited into the chaff cup or catcher, and the pressure deferential caused by the motor-blower unit caused the effluent to pass through the $1/8^{th}$

inch grid around the baffle and out through the smoke and odor filters.

After about six to eight minutes of cooling cycle, the beans were cooled sufficiently to stop the roast and retain the previously observed doneness. Due to exothermic processes within the beans they continue to heat up when external heat is removed so they are subject to external cooling slightly before the final roast color is seen. The motor-blower unit was turned off. The glass lid was removed and the roasted beans emptied out and stored in sealed glass jars. Later, as needed, the stored beans were ground and processed into a fresh cup of coffee beverage.

In another method example, cover **14** is removed and a layer or more of green coffee beans is deposited on the floor of pan **12**. The operator selects the mode, EG "Manual", and applies power to heating rod or element **40** that, in turn, heats by conduction the bottom of pan **12** and the resting beans. As the beans begin to roast the operator can inspect the bean color and listen to the roasting sounds as desired. In addition, the operator can turn the blower assembly on a relatively slow speed such as **1000** RPMs to force the smoke and steam out through the filter assembly to preserve bean visibility. The radial blower **26** draws outside air in and circulates the air generally as

shown in dotted lines in figure **1**. Because of the slow blower speed and the continued application of heating energy to element **40**, the beans remain at rest and continue to absorb roasting energy. During this phase, the blower draws fresh air into the chamber and forces air with smoke and steam out of the chamber in the path shown by the dotted lines. Some chaff that separates from the roasting beans may be carried out with the exhausting air but when the chaff clears the bottom of the baffle **21** it remains at the bottom of the cup **18** due to its weight and inertia. The smoke and steam, however, continue upward and through the filters **22** and **25** and exit the system.

If the operator notes an excessive burning smell or excessive color change in one segment of the bean body, the operator can manually press the stir button on controller **30**. This applies more power to motor **24** which increases the blower speed to cause the beans to fly outward and against the sides of pan **12** and against each other. Some beans would also circulate back toward the center of the pan in a swirling motion. In effect, the beans would be effectively stirred within the chamber. In one example, the high blower speed for a **12**-inch pan was **6000** RPM. This stirring cycle should be short, EG about **10** to **20** seconds, so that the body of beans is not significantly cooled but instead

retain most of their residual heat. In addition, it is preferred that the power continue to be applied to the element **40** so that the net cooling is reduced during this phase. Also, during this high-speed cycle, most of the chaff is carried up and out of the pan itself and deposited in cup **18**. This chaff removal and collection also aids the operator visual inspection of the roasting beans when the beans come to rest. Once the beans are stirred, the operator can manually reduce the blower speed by pressing the appropriate button on counsel **30**. Preferably, the controller reduces blower speed gradually so the beans distribute along the pan bottom. This can be done manually by rheostat control or automatically by programmed IC chip in counsel **30**. The beans will come to rest on the pan bottom where they will resume their roasting by way of the heat energy applied by conduction through pan bottom. Some of the beans may be piled up at the outer portions of pan **12**, but this will not affect the quality of the roasting method and over time, the vibrations of the system will cause those beans to migrate toward the center of the pan bottom. Also, since most beans have one flat side (the other is rounded), they tend to come to rest with flat side down for best conductive heat transfer with pan bottom.

The high and low speed cycles can be repeated as desired by the operator. In one example of the method, the slow speed cycles lasted two - to - three minutes and the high-speed cycles lasted about **20** seconds. Three - to - four cycles were needed for fully roasting the beans.

Once the beans were fully roasted, power to rod **40** was cut off and the blower set for high speed. This high-speed cycle is a rapid cool-down cycle to not only rapidly cool the beans to capture flavor but also to separate and carry off the remaining chaff from the stock of roasted beans. This cool-down cycle lasted about **6** minutes in this example.

ALTERNATE EMBODIMENTS

An alternate system **50** according to the principles of the present invention is shown in Figures 2 to 8 where common reference characters refer to similar elements to system **10**. System **50** includes metal pan **62** defining opening **14** in the pan bottom. In one example, the pan was **12** inches in diameter with four-inch high sidewalls. The pan bottom can be high finish aluminum and thick enough to cooperate with rod **40** to provide even heating to the bean layer.

A cover assembly **52** functions to close the roasting chamber, collect floating chaff, and filter most smoke and

steam from exiting gases and particles. Assembly **52** preferably includes a glass dome - shaped cover **55** with handle **53** and smoke filter **66** that preferably extends completely around the periphery of the outer edge of cover **55**. Filter **66** can be secured to cover **55** by seal **68** to form a single unit raised and lowered by handle **53**. In one example seal **68** extends along and is integral with the top of filter **66** and is shaped to releasably mate with the outer edge of glass cover **55**. A further seal **64** lines and is integral with the bottom of filter **66** and functions to releasably seal filter **66** of the cover assembly **52** to the top edge of pan **62** when assembly **52** is placed on the pan. Seals **64, 66** can comprise any suitable material such as silicone plastic. Preferably, filter **66** and its seals **64, 68** can be selectively removed from cover **55** to permit cover and filter cleaning and chaff removal as desired. It has been determined that a filter selection that blocks all but 1.0 micron particles is suitable. However, a 0.1 micron filter is preferred to prevent too much smoke for inside use but allow some smoke to exit the system for operator indication of roasting completion by the smell parameter. Alternately, a carbon post-filter can be used in combination therewith. Crackling sounds can also emanate with such filters. Assembly **52** can further include a chaff

catcher screen or mesh element **74** having an outward extending floor portion **75** connected to the lower edge of the filter **66** and an upwardly and inwardly extending part **77** that can extend to the inner surface of dome **55**, as shown, or be spaced below it. Screen **77** has openings that approximate **1/8**th inch to enable floating chaff to penetrate the screen but reject beans from such translating through. Any chaff that translates through screen **77** will be blocked from exiting the system by filter **66**. Instead, chaff will accumulate in space **78** on the top of floor **75**, where they can be discarded after the process is completed. A smaller opening, chaff-blocking screen (not shown) can be placed along the inside surfaces of filter **66** to prevent chaff from jamming the filter ports.

It will be understood that seals **64**, **68**, filter **66** and screen **74** are shown extending completely about the system periphery as represented by the dashed lines. However, it would be within the scope of the invention for these elements to extend substantially about the periphery so long as they function to remove substantial smoke to permit inside, non-vented use and allow some odor to emanate to aid the operator. By extending completely about the periphery, assembly **52** maximizes the exhaust area, the area to filter the smoke, and the space to catch the chaff.

This arrangement also enables the same size filters to be stacked one atop the other (not shown) to increase these capacities even further for restaurant applications or applications where a lot of beans are roasted to a dark color, resulting in a great deal of smoke.

Motor **24** and controller **30** can be mounted to the pan or to the legs or to some frame member (not shown) as desired. Radial blower **70** draws air from outside the system and provides air circulation as further described below. Screen or mesh **72** can be mounted on the floor of the pan about blower **70** or at attached to the blower periphery to prevent beans from engaging the rotating blower blades **73**. Only part of screen **72** is shown for simplicity. The motor is positioned so that the blower **70** is inside the heated space. The motor **24** is outside the heated space and in the flow of the incoming cold air stream which keeps the motor cool. A flat baffle or disk, such as **82** of the embodiment of Figure **8**, can be added on top of the motor but below the bottom surface of the pan to keep the motor even cooler and during the final cooling operation to draw cooling air in across the outside bottom surface of the pan, thereby decreasing the cooling cycle time.

In operation, one or more layers of green coffee beans are spread on the floor of pan **62**. Power is applied to

heating element **40** that heats the bottom of pan **62**. The pan bottom, in turn, heats the resting beans by conduction. Simultaneously at the start of the heat application or shortly thereafter, blower **70** is activated at slow speed, EG **1000-1500** RPM, to remove smoke and steam. Blower **70** draws outside air in through opening **14**, circulates it outward and circumferentially. See Figure **3**. This relatively slow-moving circulating air carries the smoke and steam in a swirling motion and upward and outward pattern, thence out through screen **74** and filter **66**. Note the beans continue to rest and roast for the heat energy applied by element **40** is sufficient to roast the beans regardless of the cooling effect applied by the slow moving air. In addition, the operator can easily visually and audibly monitor the roasting beans for color and crackling sounds because the smoke, steam, and chaff are carried away by the slow moving air, and the slow speed blower generates little noise.

The operator, upon judging that stirring the beans would be beneficial or necessary, can manually control motor **24** to cause blower **70** to rotate at high speed, EG **6500-7000** RPM for a short **10 - 20** seconds. Blower **70** generates high-speed air drawing and circulation. This action causes the mass of beans to swirl toward the outside

portions of the pan **62**. However, because blower **70** also applies a circumferential vector component to the blown air, the mass of beans also moves circumferentially about the pan. See Figure **4** and **6**. It is noted that the beans located more toward the pan center move circumferentially more rapidly than beans located more toward the pan outer walls. The main purpose of this swirling action is to stir the beans and to separate chaff and remove chaff and smoke and steam, not to cool the mass of beans because the roasting thereof has not completed. Accordingly, the high-speed blower cycle should be short and the power to element **40** should remain on during these high-speed cycles. With this method of mixing the more-roasted beans which are lighter are thrown up higher than the denser less-roasted beans during mixing. So the less-roasted beans should be closest to the heating surface once a mixing cycle is complete and the beans have redistributed and come to rest.

Once the beans are sufficiently stirred, the operator or the system automatically, shifts the blower to slow speed and the beans come to rest again on the pan bottom. Some beans will initially remain piled up along the sidewall, however, the natural vibration of the system tends to cause the beans to spread out somewhat toward the pan center. To better redistribute beans after stirring,

it is preferred to gradually deaccelerate the blower so the centrifugal force is decreased and as the blower slows down beans are deposited in an ever-decreasing circle on the pan bottom. As the blower goes through its resonant speed on the way down, vibration causes the mass of beans to move towards the center from the outside. If desired, the pan bottom can have a slight central, conical slope from the outer edge. A 12-inch pan, may have a 1 to 2 inch descent and a smooth surface inside the pan to distribute the beans across the surface more evenly. The slow and high-speed cycles can be repeated as desired until the beans are fully roasted and show a desired color, sheen, sound, and/or odor. In one example, the slow speed cycles extended for **3** - **4** minutes and the high-speed cycles extended for about **20** seconds. The beans were fully roasted in **3** - **4** complete cycles.

Once fully roasted, it is preferred that the beans be quickly cooled to preserve flavor in the beans. System **50** applies rapid cool down by simply operating blower **70** at high speed and cutting power to rod **40**. As mentioned above, this action draws cool air into the system, swirls the beans to cool them, and forces heated air out through the filtering system. In one example, the cool down cycle lasted **6** - **9** minutes. Cover assembly **52** was then removed

and the cooled beans placed in jars for storage. These beans were later ground and used to make a fresh coffee beverage.

Although alternating low air speed phase and high air speed phase are mentioned above, it is within the principles of the present invention that other air off phases or intermediate air speed phases and transition phases can be employed with the present systems and methods as desired.

It should be understood that, as long as the amount, coffee type, and required roast result remain the same, parameters can be pre-programmed for the automatic mode of operating systems **10** and **50**. Results from these pre-programmed systems would be substantially uniform from roast-to-roast. Systems **10** and **50** are also relatively quiet permitting the operator to hear all crackling sounds. The beans roast while at rest so that the operator can see the color of individual beans, see the slight movement of individual crackling beans, and hear the crackling. The present method also enables the beans to retain a significant amount of their natural oil while eliminating moisture which produces a better-flavored product. A blower wheel with radial and/or curved blades creates a strong current of air to cool the beans, carry the chaff,

and enough static pressure head to push air through a 0.1 micron filter. Also, it uniquely creates a swirling motion (not just a radial motion) which rotates and turns over the entire bean mass, thereby cooling and/or mixing the beans very efficiently. With the present system **50**, the balance between blower, filter, motor, heater, smoke, cooling are such that this process is balanced and can be based on a 15-amp 115 volts circuit, i.e. standard house power, if desired. The present invention also facilitates a scaled up system so that more coffee beans can be roasted in a given roast cycle. For example, a 24-inch diameter pan can be used with generally a 220-volt 20-amp circuit to roast about 7 pounds of green beans. Also, a drop or rise in line voltage will not significantly affect the roasting cycle because heat transfer is in direct proportion to applied voltage. For example, a $\pm$ 10% line voltage variation results simply in a $\pm$ 10% heat transfer variation, which is insignificant to the overall cycle when compared to the known systems fluidized bed or drum type, which rely on radiant heat transfer.

It will be understood that various changes and improvements can be made to the herein disclosed exemplary embodiments without departing from the spirit and scope of the present invention.